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**PORTO RICO AGRICULTURAL EXPERIMENT STATION,  
MAYAGUEZ, P. R.**

**Under the Supervision of the  
UNITED STATES DEPARTMENT OF AGRICULTURE.**

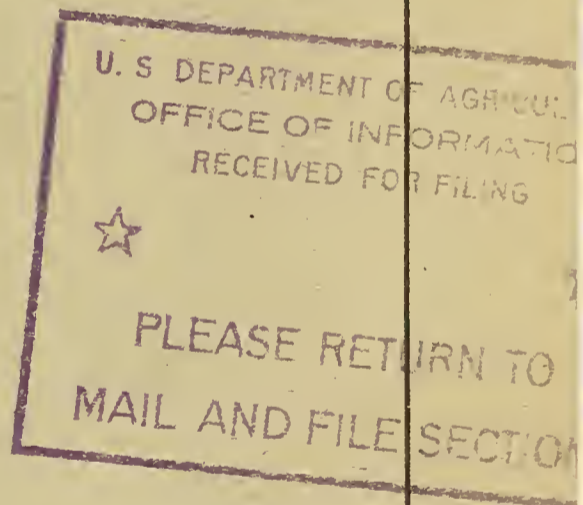
**REPORT OF THE PORTO RICO  
AGRICULTURAL EXPERIMENT  
STATION.**

**1922.**

▼  
**Issued December 14, 1923.**



**WASHINGTON:  
GOVERNMENT PRINTING OFFICE.  
1923.**





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## PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of the States Relations Service. United States Department of Agriculture.]

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# PORTO RICO AGRICULTURAL EXPERIMENT STATION

MAYAGUEZ, P. R.

Under the supervision of the  
UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.



December 14, 1923

## REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1922.

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### REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. MAY.

The proper function of an experiment station is research, and instruction should not be expected of it. For many years after the establishment of the Porto Rico Experiment Station it was necessary to translate its work to a public not familiar with scientific agriculture. Fortunately this period is passed and the station can now turn more to the investigation of tropical agriculture, leaving to other agencies the popularization of its work.

#### FERTILIZERS.

The prosperity of the island depends primarily upon agricultural production, which in turn is contingent upon soil conditions. Nitrogen is the limiting factor in soil fertility and the largest element of expense in the annual fertilizer bill of the country. The imports of fertilizer, the greatest part of which was nitrogen, amounted in 1921 to 52,969 tons, valued at \$3,165,611. The most inexpensive and practical method of supplying this element would seem to be in the growing of legumes. In the Tropics, where there is a 12-month growing season every year, legumes should be grown in rotation with cane and other crops, as they are well furnished with nitrogen-storing bacteria and yield large quantities of peas and beans for human consumption and forage for stock. Large numbers of valuable leguminous plants, including the velvet bean and *Tephrosia candida* for coffee plantations and pastures, and the soy bean and sword bean for forage and green manure, have been introduced by the station.

Many of the heavy soils, especially in the interior, require liming to neutralize the acidity and bring about better tilth. In various sections of the island there are many deposits of natural lime that is soft enough to be cut with a spade and spread over the fields. Planters should determine the lime requirement of their soil and then apply this element in the best form commensurate with the cost.

#### VEGETABLE GROWING.

With few exceptions, every vegetable that grows on the mainland can be grown in Porto Rico. Notwithstanding this fact, few vege-

tables ever reach market, due to the prevalence of insect and fungus pests and to the inertia of many farm hands who would rather hire their labor in an overcrowded market than produce crops for themselves. With a view to remedying this defect the station has, by the distribution of seeds and the dissemination of practical information relative to vegetable growing, sought to encourage the raising of vegetables at home.

Radishes, turnips, and carrots are easily grown in Porto Rico and are troubled by very few pests. Turnips grow quickly and the tops are available as greens. Successive plantings of this crop should be made, as the roots become tough and bitter. Beans, which are largely imported for use with rice, should be grown to supply local needs and for export as they were during the World War. Both the garden and sweet pea can be successfully grown when the soil is inoculated with nitrogen-fixing bacteria. Of the former, the tall growing sorts give the largest yields and over the longest periods. Inoculated soil should be obtained from the station for use in growing peas, and the crop should be grown in the winter. Lettuce ranks first among the salad vegetables and is now grown quite extensively. Of the many varieties tested by the station, Mignonette has given the best results, heading nicely and being crisp and tender. The seed of lettuce should be sown in boxes which are protected from ant invasion. Kale and Chinese mustard are among the easiest crops to grow. Swiss chard does well and gives a number of cuttings. Okra is the surest all-the-year-round crop, and does well during even the time of heaviest rains. The improved varieties are much better and more prolific than the native kinds. Peppers, onions, tomatoes, beets, eggplants, kohl-rabi, cabbages, and cucumbers should be grown in every garden. Only the improved seed of eggplants should be used, as the native varieties run to seed and are thin-fleshed.

#### PLANTING SEASONS.

The temperature of Porto Rico is always conducive to plant growth, yet the time of planting is modified by rainfall, and occasionally by periods during which certain insects are abundant. There are no such limits to time of planting in the Tropics as in the Temperate Zone, and the ground should always be covered with some crop. Thirty days is sufficiently long for the growing of a leguminous crop such as the cowpea if it is to be turned under for green manure or fed.

One of the causes of delay in seeding and planting in Porto Rico is the widespread belief in the supposed influence of the moon on plant growth, many native farmers believing that some phases of the moon are more favorable for planting certain crops than others. While those connected with the station do not hold to such belief, it was thought advisable to conduct a demonstration to show that other conditions being advantageous it was not necessary to wait on the phases of the moon. Seeds of radish, oats, and sunn hemp (*Crotalaria juncea*) were sown at six weeks' intervals throughout the year, advantage being taken of seeding in all the phases of the waxing and waning moon. Other lots were grown under conditions excluding moonlight, and in still others six different soils were seeded under like conditions. Many hundreds of the resulting plants were weighed and measured, but no striking or consistent differences were

found. Such slight variations as were noted were not sufficient to influence the general growth of the plants over the whole period.

### LIVE STOCK.

Much progress was made during the year with live stock, especially with dairy cattle. Quite a number of purebred dairy animals were imported as a result of the successful introduction of other such animals at a number of places following the active campaign for the eradication of the cattle tick (*Margaropus annulatus*), and the numerous demonstrations by the station of the growing of improved, nutritious feeds.

Data pertaining to dairying in Porto Rico were submitted for publication during the year.<sup>1</sup>

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## REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By L. G. WILLIS and J. O. CARRERO.

### RICE INVESTIGATIONS.

A study of some of the critical factors governing rice production has led to results that are of value not only to rice growers, but also probably have a bearing on certain phases of the culture of other crops.

Former investigations made to determine the relation of fertilizers and soils to the apparent physiological reaction of the rice plant, showed that chlorosis of rice, due to lack of iron, is associated with the presence of an excess of calcium carbonate in the soil. Investigations conducted during the year indicate that this effect is further governed by the nature of the fertilizing materials used in growing the crop. In other words, fertilizer compounds which in themselves or by virtue of a nonassimilable basic residue tend to precipitate iron are usually associated with the development of chlorosis, while fertilizers having nonassimilable acidic residues are effective in preventing chlorosis on a moderately alkaline soil.

Although rice is not a crop of great economic importance in Porto Rico, it serves well for use in experimental culture, being like many other plants in its physiological reaction to chlorosis on calcareous soil. The results obtained with rice probably explain the observation made in many experimental and commercial plantings, that sodium nitrate is valueless, while ammonium sulphate is highly satisfactory as a fertilizer for pineapples, and suggests that chlorosis of corn and of cane, as well as the frenching of citrus trees, can probably be remedied in many instances by the use of ammonium sulphate in the fertilizer formula.

It was also observed in the experiments with rice that excessive applications of nitrogenous fertilizers to plants grown on a compact soil caused a sterility which appeared to be the so-called straight-head disease. The occurrence of this trouble was governed by the quantity of nitrogen supplied and by the management of the soil with respect to irrigation. Plants made normal growth with nominal quantities of nitrogen regardless of whether the soils were flooded

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<sup>1</sup> Porto Rico Sta. Bul. 29, Dairying in Porto Rico, copies of which may be had by addressing the agronomist in charge of the station.

continuously or intermittently, and were less subject to sterility when grown on soils that were flooded intermittently.

Analytical work on samples of rice grown with the various soil treatments is nearly completed, and it is hoped that some differences in composition may be found to throw light on the physiological causes of the observed sterility. Early observations indicate that the sterile condition is associated with an excessive accumulation of nitrogen in the plant tissues, and it is possible that the results obtained with rice may explain similar conditions in other economic plants. No doubt this investigation could be developed to include a study of the factors governing the time of blossoming of citrus trees, with results of great financial value to Porto Rico.

#### WORK WITH AGRICULTURAL LIME.

The interest which is being aroused in the use of ground limestone as a corrective of acidity of certain soils that are devoted to miscellaneous crops made it advisable to start an investigation to determine the relative value of the most abundant types of limestone. This work will probably be continued and reported upon next year. Liming may be expected to yield profitable returns on all acid soils excepting very sandy soils and with most crops excepting pine-apples.

#### MANAGEMENT OF CANE SOILS.

In a further study of the nitrogen economy of cane soils it was found that nitrogenous fertilizers do not greatly increase the yield of the first cane crop and leguminous green manures are apparently of no advantage. The early growth of the canes' first ratoon, however, showed the effect of not having received nitrogen. The growing of cowpeas between the cane rows as a green manure to supply nitrogen to the soil resulted in a noticeable improvement in the appearance of the cane as compared with that in the check plats, but no conclusions can be drawn relative to the efficiency of this method until the experiment has been carried on for some time.

#### ANALYTICAL WORK.

The analytical work in connection with the projects of the division has taken so much of the available time that there has been little opportunity to undertake any miscellaneous analyses. Samples of juice from seedling canes were analyzed and a number of samples of ground limestone were tested for purity.

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### REPORT OF THE HORTICULTURIST.

By T. B. McCLELLAND.

#### LEGUMES.

With irrigation, garden and field beans may be planted in the early winter with a fair assurance of dry weather for maturing the crop. Late winter or early spring planting should be made if a large crop is wanted. Two plantings were made at the station during the year, one in autumn and the other in spring. A severe drought followed the spring planting and so retarded germination that many plants failed to emerge from the ground until five weeks

after planting. Notwithstanding the long delay in germination, a fine stand and a heavy crop were obtained. Practically the whole crop was ruined between June 5 and 10, however, by the fall of 8 inches of rain, which flooded most of the field for days. Among the selections saved were various white strains which were derived from a cross with black Venezuelan and have been carried through several generations. In the progeny of this cross blackness of the seed coat is dominant over whiteness, and glossiness over dullness. The progenitor, presumably  $F_1$ , was a glossy black bean found in a row of black Venezuelan. The  $F_2$  generation consisted of 1 glossy white, 2 glossy black, and 1 dull black type. The white threw only white in the  $F_3$  generation, 5 glossy and 1 dull. The dull black threw only dull, 6 of which were white and 15 black. The glossy black threw 2 glossy and 1 dull white, and 9 glossy and 5 dull black. The  $F_3$  generation from the two  $F_2$  blacks then consisted of 9 white and 29 black. The  $F_4$  generation from the 9 white-seeded plants consisted of 239 white and 1 black, the latter presumably the result of further crossing. Of the 29 black-seeded plants, 1 was discarded, 11 threw black only, and 17 threw 469 black-seeded and 151 white-seeded plants, a very fair ratio of 3 to 1.

From the two  $F_2$  glossy beans, 7 dull and 16 glossy types were derived. The dulls all bred true for dullness. Of the 16 glossy-seeded plants the classification of the progeny of one, 6 glossy and 4 dull, was doubtful because of immaturity. Of the 15 others, 3 produced only glossy-seeded plants while 12 produced 255 glossy-seeded and 90 dull-seeded plants in the  $F_4$  generation. Among the dull-seeded plants varying degrees of dullness or lack of gloss occurred.

Cover crops have been limited to two genera, *Tephrosia candida* and *Crotalaria* spp. The effect of the length of day, and in consequence the season of planting, was very pronounced on *T. candida*, plantings of which were made every season. Of eight species of *Crotalaria*, which were planted for comparative purposes, *C. juncea* at  $2\frac{1}{2}$  months after seeding had made the best development.

#### ROOT CROPS.

*Sweet potatoes.*—Of 36 varieties tested, Key West again led in production, yielding a little over 132 pounds of roots, or more than  $2\frac{1}{2}$  pounds per linear foot of row. White Belmont ranked second, with a production of  $108\frac{1}{2}$  pounds, or approximately 2 pounds to the linear foot. The planting was made in better soil than was the case last year, and the yields were much higher. The most promising varieties have been distributed.

*Yams.*—The yam crop was planted in much poorer soil than the year preceding, and gave in consequence much smaller crops with a smaller difference in yield between the staked and unstaked vines. In eight of the nine varieties grown, the yield of staked vines exceeded that of unstaked, and in the other the difference was less than 1 per cent. For the whole planting the staked vines averaged a 41 per cent greater yield than the unstaked. A recent yam acquisition, S. P. I. No. 46801, led all varieties in yield, exceeding its nearest competitor by 20 per cent and all competitors grouped by 77 per cent.

*Yautias and taros.*—In a test with 8 varieties of yautias and 4 varieties of taros, a spacing of 18 by 36 inches was compared with one 36 by 36 inches. In each variety the wide spacing gave greater

yields per individual plant, and for each taro variety the yield from equal areas was greater with the wide spacing, but for 7 of the 8 yautia varieties the yield from the narrow spacing exceeded that from the wide spacing for equal areas planted. If the yautia varieties are considered as a unit, the yield from the narrow spacing would be 19 per cent greater than from the wide spacing.

#### MANGOES.

The mango orchard now contains more than 500 grafted trees and numerous seedlings. It is thought that in time the collection of trees in this orchard will be one of the most comprehensive in the Western Hemisphere. During the year 41 seedlings, springing from 15 seed of a polyembryonic variety, Cambodiana, were added to

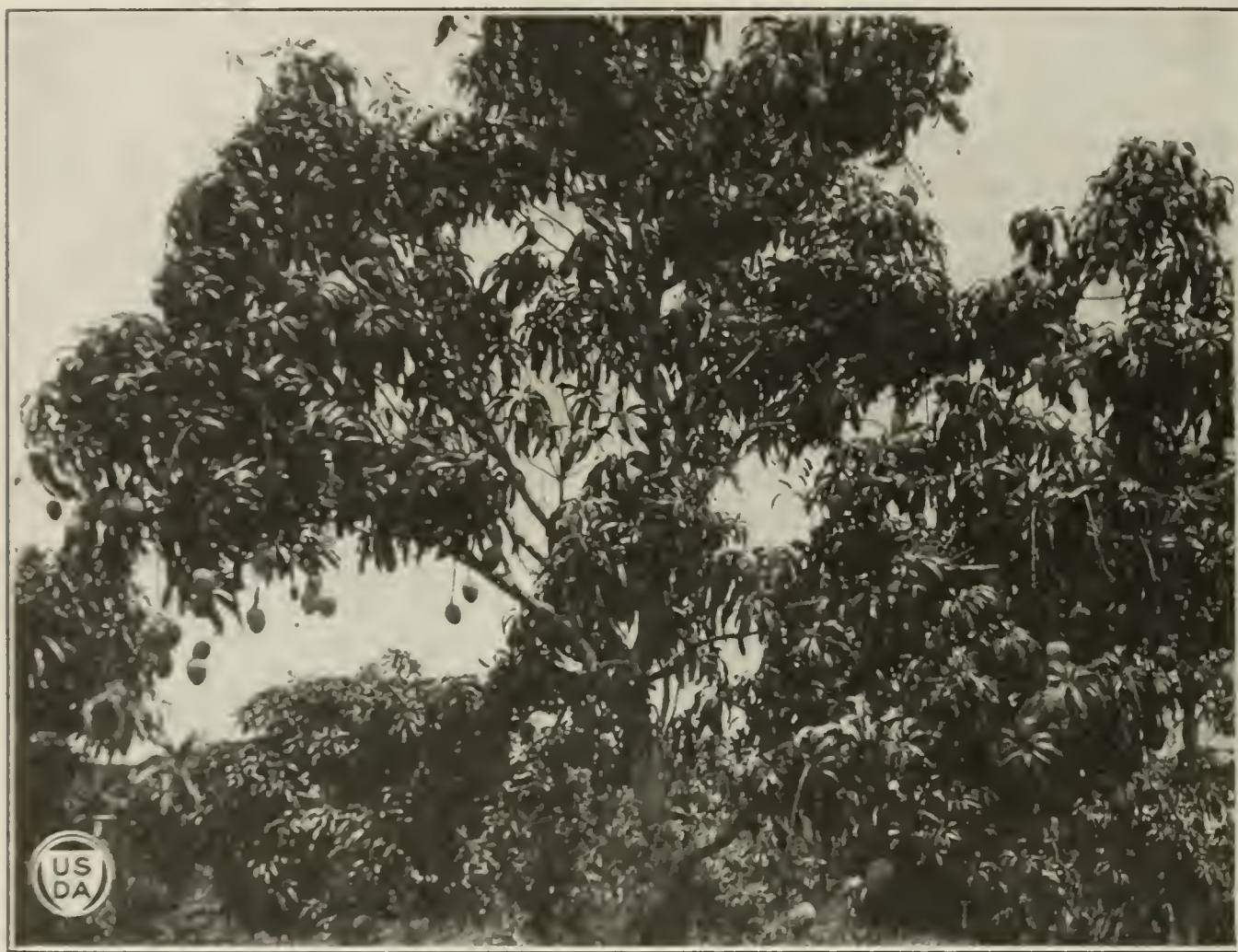


FIG. 1.—Fernandez mango (S. P. I. No. 19117). Tree bore over 200 fruits.

those already in the field to test their variation. Of those which have fruited to date, approximately half have come true to the parent type, and the others have shown some variation, but in most cases not enough to lessen their market value greatly.

The crop was unusually heavy this season, but was partly destroyed by the melon fly. Eight Philippine seedlings (Pl. I, fig. 1) bore fruit, most of which was diseased or fly stung. Practically all of those tested contained a high percentage of acid, due probably to premature dropping and ripening.

The variety *Mekongensis* fruited this season for the second time. In appearance and manner of production the fruit resembles the Philippine variety, but lacks the disagreeable acidity of the latter and ripens better. Representative fruits weighed from 200 to 350 grams (7 to 12 ounces). In form the fruit is elliptical, except for a concave depression on the apical half of the ventral side. In color it

varies from greenish yellow to deep yellow, tinged occasionally with pink. The texture is good, but somewhat more fibrous than that of the variety Cambodiana, to which both Mekongensis and the Philippine mango are closely related.

Chempadan, a variety introduced from Ceylon, fruited for the first time in sufficient quantity for testing (Pl. I, fig. 2). In this variety sweetness and acidity are well proportioned, and the flavor is very pleasant. The general form of the Chempadan is sub-ovoid, and in cross-section, round. In color it is orange, dotted with numerous green and black lenticels, and shows some russeting and a

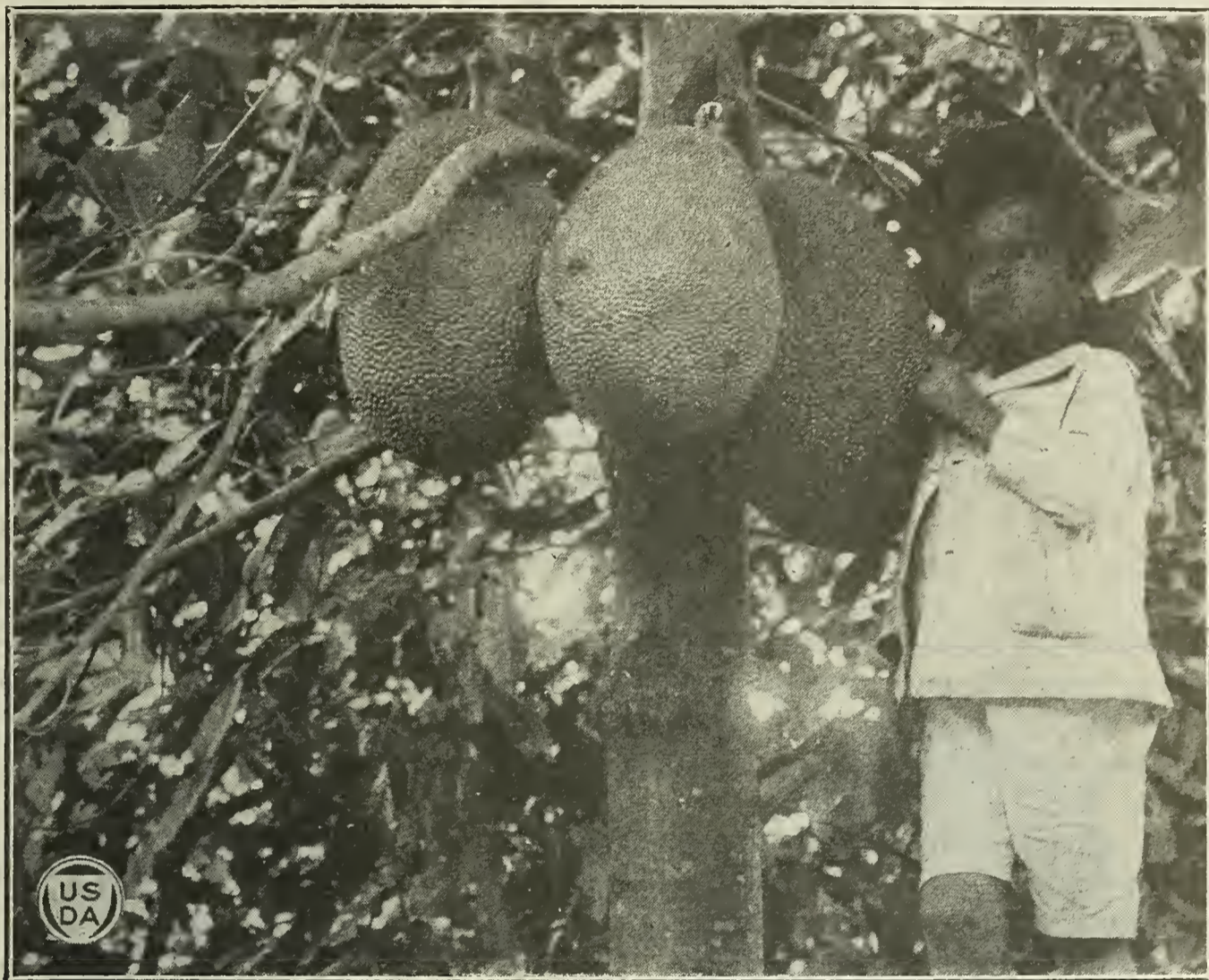


FIG. 2.—Jack fruit. Weight,  $29\frac{1}{2}$  pounds; seeds,  $2\frac{1}{2}$  pounds.

faint gray bloom. Fiber is thickly set over the ventral margin of the seed, but it is not as objectionable as that found in the Porto Rican mango. Representative specimens weighed from 125 to 300 grams (4 to  $10\frac{1}{2}$  ounces). Nearly all the fruits were found to be injured by larvæ of the melon fly, the interior showing a corky development instead of the usual soft rot occurring in Cambodiana and a number of other fly-infested varieties.

Fernandez (fig. 1) and Itamaracá fruited well and continue to give promise as valuable varieties for this locality in regard to both quality and quantity of fruit.

#### AVOCADOS.

Of a large number of Guatemalan avocado trees which were received in 1919, several blossomed during the year and set fruit which later dropped. The trees are rather small as yet, but their early fruiting tendency is promising.

### JACK FRUIT.

The jack fruit (*Artocarpus integrifolia*) bore some large fruit during the year. (Fig. 2.)

### COCONUTS.

The coconut fertilizer work was considerably extended during the year, cooperative experiments being conducted in three different localities. In a plantation of 8-year old coconut palms where the average yield in 1921 was only 11 nuts per tree, a yield averaging 45 nuts per tree was made on a plat to which common salt (sodium chlorid) had been applied. This plat continues to outyield other plats which received various fertilizer combinations. Having shown such pronounced effects here, sodium chlorid is being tested on an extensive scale in another plantation and on a third in contrast to two forms of potash. Nearly 500 palms are included in the coconut fertilizer work and individual records are kept of each palm.

### COFFEE.

The cooperative fertilizer test with coffee was continued during the year as outlined last year.<sup>2</sup> Indications are that nitrogen and potash are relatively more important than is phosphoric acid as a fertilizer for coffee on the soil tested. It might, however, be advisable to apply a complete fertilizer if mineral fertilizers are to be used. The form of nitrogen continues to show itself most important in a field test under way. The trunk diameter of trees which were fertilized with ammonium sulphate was 22 per cent greater than that of trees fertilized with sodium nitrate, while the crop of the past season was 72 per cent greater for the former than for the latter. It is thought that the fertilizer experiments with coffee have progressed sufficiently to permit of the publication of the results within the near future.

Among the imported coffees, Excelsa is very promising for planting in certain sections of the island where the leaf miner severely damages the Arabian coffee. In growth this variety is very vigorous and in yield it is promising, the second crop from a planting of 40 trees averaging more than 4 liters (3.8 quarts) of berries per tree. This is the best of the coffees of the Liberian group so far tested by the station.

### VANILLA.

Experimental work under way with vanilla had to be abandoned due to a root disease, presumably *Fusarium* sp. One planter marketed over 200 pounds of cured beans from his first crop and estimates that there are still 1,000 pounds or more on the vines. It is hoped that the success attained on this plantation may serve as an inducement to others to grow vanilla, more especially where old coffee trees are to be replaced. This may be done by interplanting coffee with vanilla after the old shade has been removed. By the time the new shade, which also serves as a support for the vanilla, is established and the vanilla comes into bearing, the old coffee trees may be removed and younger trees set throughout the planting. In this way the coffee may be renewed in connection with vanilla plantings at little expense. The land may be used for a single planting of vanilla, or it may be occupied by vanilla through a number of years.

<sup>2</sup> Porto Rico Sta. Rpt. 1921, p. 12.



FIG. 1.—PHILIPPINE SEEDLING MANGO.



FIG. 2.—CHEMPADAN MANGO.

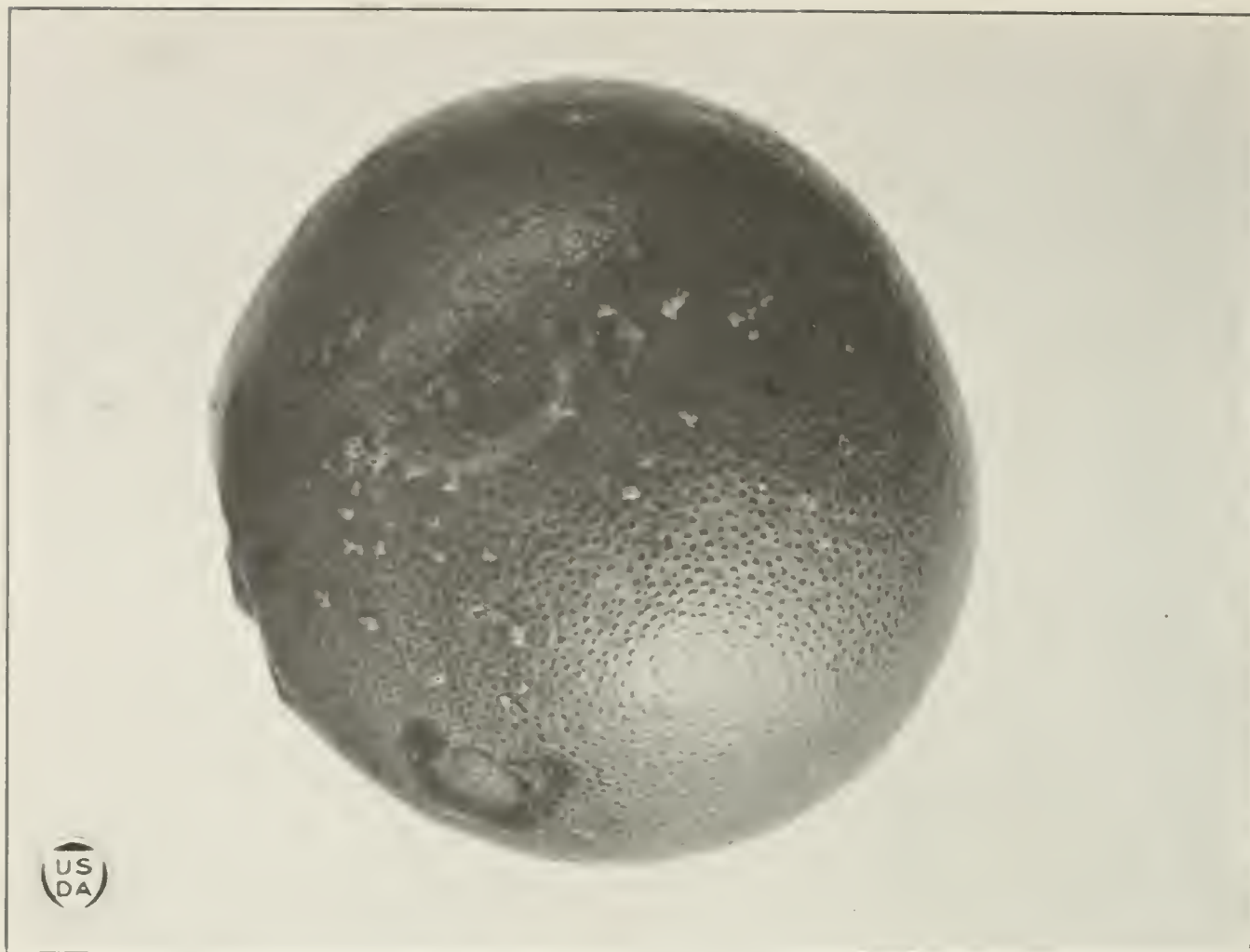


FIG. 1.—GRAPEFRUIT SHOWING TRACE OF SCAB.

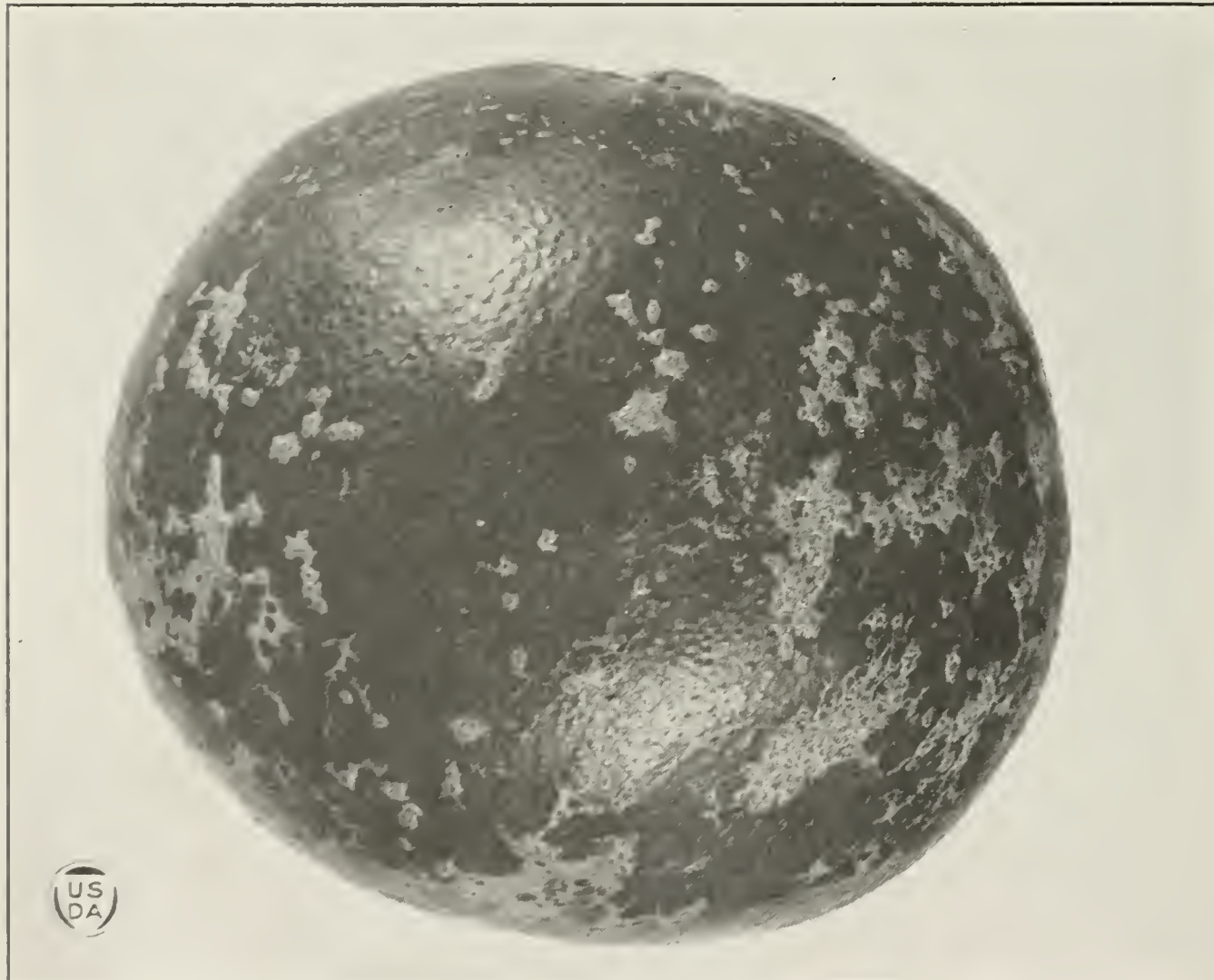


FIG. 2.—GRAPEFRUIT SHOWING SOME SCABBY AREAS.



FIG. 1.—GRAPEFRUIT. BADLY SCABBED, BUT NOT KNOTTED.



FIG. 2.—GRAPEFRUIT. BADLY SCABBED AND KNOTTED.



FIG. 1.—SOUND GRAIN.

INFECTED GRAIN.



FIG. 2.—GERMINATING INFECTED GRAIN. NOTE ABSENCE OF ROOTS.



FIG. 3.—CHARACTERISTIC SPOTTING OF LEAVES.  
HELMINTHOSPORIUM DISEASE OF RICE.

## REPORT OF THE PLANT BREEDER.

By THOMAS BREGGER.

## GENERAL WORK.

During the year work was continued with corn, rice, eggplant, soy beans, cowpeas, and mungo beans.

*Corn.*—An ear-to-row cooperative experiment, having for its object the isolation of good strains of corn that are well adapted to the region and the demonstration of the value of seed selection over crib selection, was conducted in southwestern Porto Rico during the year. At the station Venezuelan corn from the delta of the Orinoco and native corn are under trial.

In the work of cross-breeding native corn was pollinated with Venezuelan and with sweet and field corn from the mainland. A few  $F_1$  progenies of crosses with Venezuelan and mainland field corn varieties produced a small quantity of seed notwithstanding the insufficient irrigation. These second-generation seeds were planted with remnants of the first generation in the crop for 1922.

*Rice.*—Of the 178 different varieties or strains of rice which were turned over to the plant breeder in 1920, 118 came from the mainland and 60 were selected from native rice. With the cessation of the co-operation of the office of cereal investigations, Bureau of Plant Industry, United States Department of Agriculture, due to lack of funds for adequately carrying on the work, it became necessary to reduce the number of strains.

All the varieties were grown on the dark clay bottom lands of the station in 17-foot rows 3 feet apart. Every fifth row was planted to the Honduras variety and every tenth row to Wataribune rice as a check. Available records of four different plantings made during 1918–1920 show that the mean yields of Wataribune were too low to permit of the elimination of a greater number of strains, and the Honduras variety was used therefore instead. All strains exceeding the mean yield in two or more plantings were saved. Of these, 29 from the mainland and 11 from Porto Rico were selected for further trial.

*Cowpeas, soy beans, and mungo beans.*—While the yields of cowpeas for the two years are as yet scarcely comparable, it is interesting to note that New Era, a variety originated by the Hawaii Experiment Station, ranks first in yield for both 1921 and 1922. Conch and Brabham are consistently low for the two years. Seeds of many varieties of cowpeas have been introduced and distributed by the station within the past 20 years, but it has not been possible to follow up these distributions to determine what degree of success they have attained.

Of six varieties of soy beans, Biloxi and Ootootan set a large number of pods, but were attacked by a disease which caused practically all of the seed to shrivel in the pods. Only sufficient seed for one plat was obtained of the Hahto variety and it germinated poorly. Individual selections of this variety are being made in the hope of obtaining a strain that is more adaptable to Porto Rico than the present type. Hahto has fairly large, flat green seeds suggestive of Lima beans and might be useful in the human dietary as a substitute for them, either dried or green. Individual selections of Mammoth and Haberlandt soy beans were also made and planted

in progeny rows, and mass selection of mungo beans and cowpeas were carried on.

*Eggplant*.—First generation plants of a cross between New York Improved and the native striped Pompona were grown during the winter and the yield per plant and measurement of individual fruits were recorded. The fruit of the hybrid is of intermediate size and shape and of purple color showing the underlying striped pattern of Pompona near the apex. Seeds from matured fruits of the first generation plants were saved with a view to making extended plantings of the  $F_2$  plants.

*Kidney beans*.—Mass and individual selections of the red kidney bean, known on the local market as Americana, together with an anthracnose-resistant white bean, obtained from Cornell University

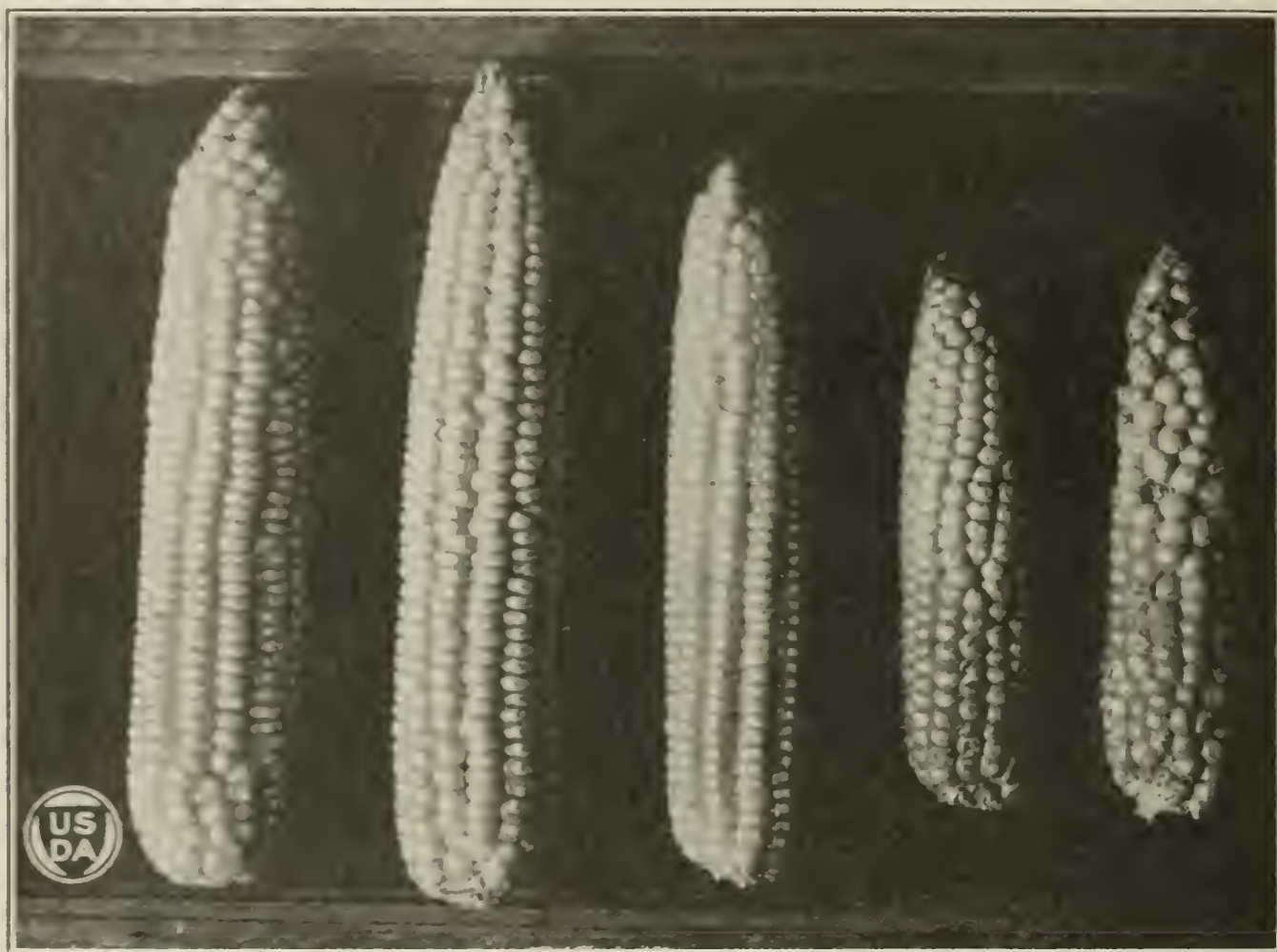


FIG. 3.—Native white corn. Space between rulers, 9 inches.

under the number F13, were planted to obtain natural crosses from which a strain of disease-resistant white bean, adapted to Porto Rico conditions, might be developed.

## REPORT OF THE ASSISTANTS IN PLANT BREEDING AND HORTICULTURE.

By W. P. SNYDER and J. A. SALDAÑA.

### SUGAR CANE.

Due to the unusually poor germination of arrows, the work in seedling cane production was a disappointment this year. About 15 protected crosses were attempted, not one of which produced a seedling. Bud selection with cane has been started to obtain (1) strains having a high sucrose content, (2) stools having a large

number of canes of greatest vigor, and (3) stools having the greatest weight.

#### FIELD CORN.

A small planting of field corn was made in January in order that studies on correlation between plant characters and yield might be continued. (Fig. 3.) Tests in which selection is based on plant and ear characters are being continued. Several abnormal characters have appeared in the self-pollinated strains as well as in some of the open-pollinated types.

#### SWEET CORN.

The station is still endeavoring to develop a variety of sweet corn that will be adaptable to island conditions. Some progress

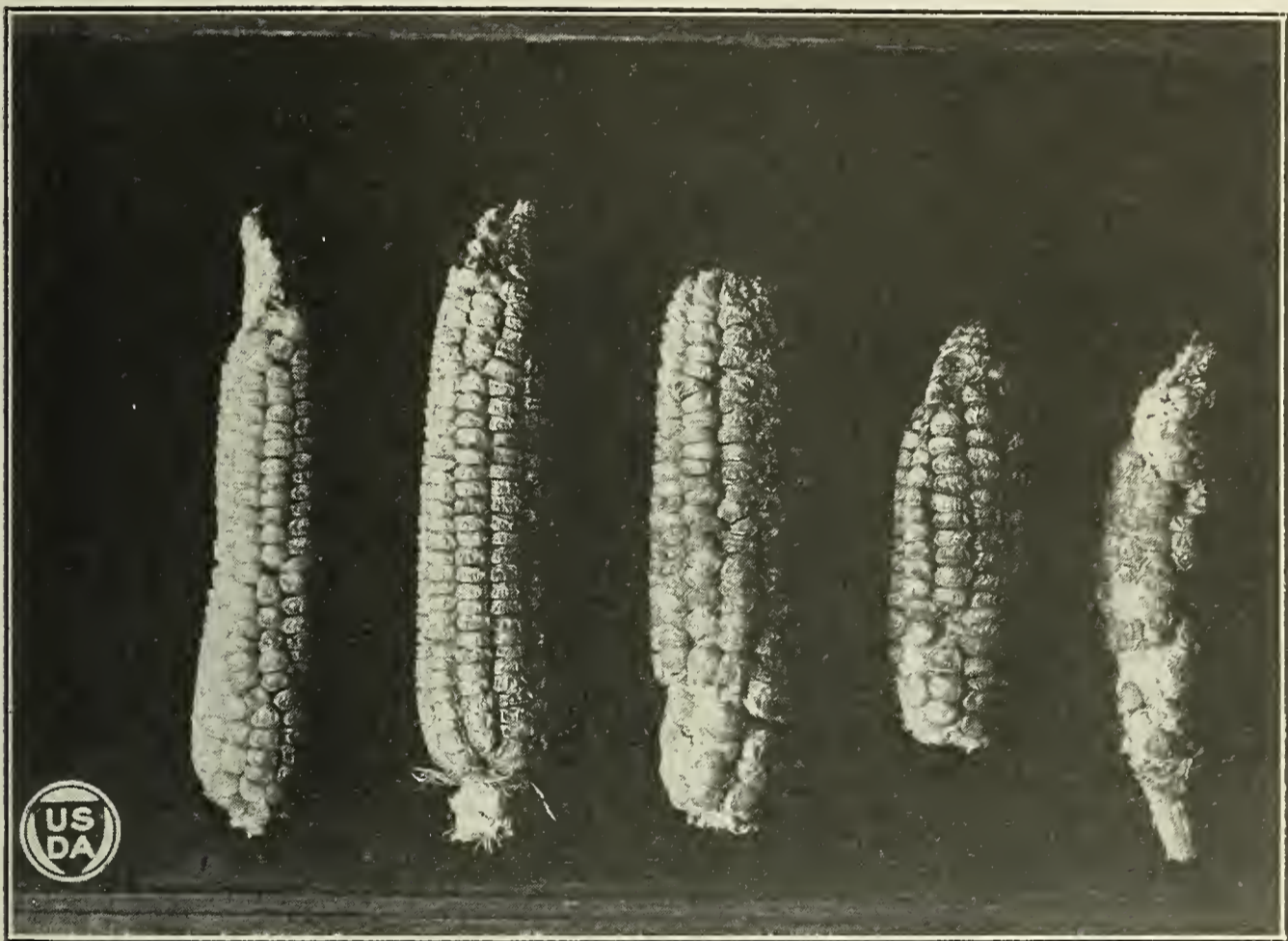


FIG. 4.—Native white  $\times$  Henderson's sugar corn. Space between rulers, 9 inches.

has been noticed in the  $F_3$  plants and in the  $F_4$  ears of the hybrid under consideration. The parents of the hybrid (fig. 4) are Henderson's Sugar, a vigorous variety of sweet corn, and a white native variety of field corn. Henderson's Sugar failing to produce seed, the station is continuing its experiments with Henderson's Astor for comparison with the hybrid corn. Henderson's Sugar and Henderson's Astor are very much alike. In height, number of rows of kernels, and period of maturity, the hybrid occupies an intermediate position between the parents. Of 196  $F_3$  hybrids, 131 were vigorous, which feature is very much desired in the work of hybridization. Henderson's Astor produced no vigorous plants. The white native corn produced 90.7 per cent vigorous plants in 1922, and a slightly less number in other plantings. Yield, based on 69 plants, for three types, was in the order of merit for the 1922 planting, white native corn, 6.11 kilograms (13 pounds 7 ounces), hybrid, 2.6 kilograms (5 pounds 11 ounces), and Henderson's Astor, 125 grams (4 ounces).

## WHEAT.

Varieties of Indian wheat were again tested on a small scale during the dry season. The kernels of many of the varieties were considerably shrunk and the yield of grain was very poor, the crop having been severely damaged by a fungus resembling a *Helminthosporium*. (Fig. 5.) Seed of the few plants making vigorous growth and producing a good crop of plump kernels was saved for

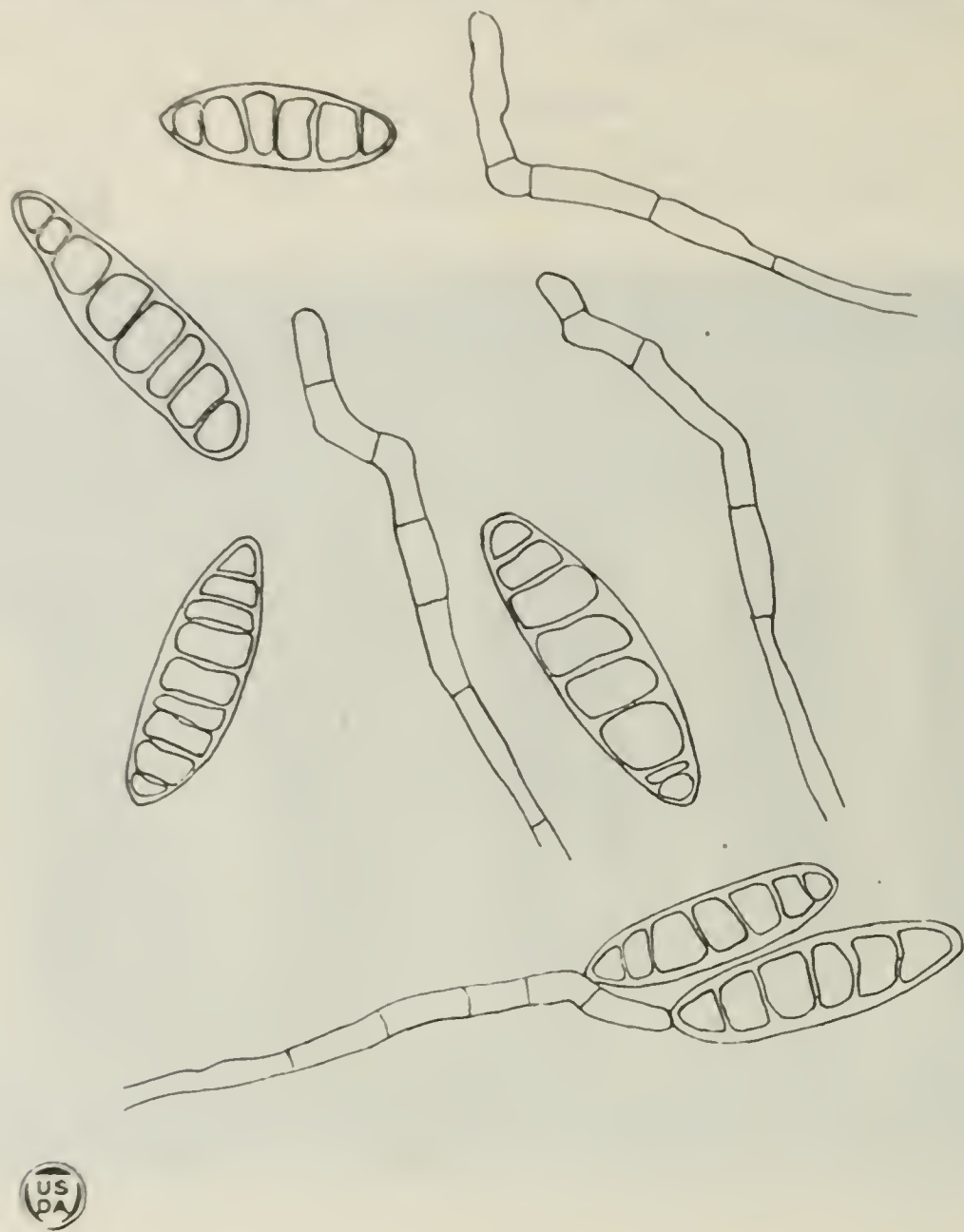


FIG. 5.—Conidiophore and spores of *Helminthosporium* sp. from wheat.

further trial. A crop is being grown under glass to multiply the more promising kinds and to permit of the observation of the effect of different soil treatments on yield of grain.

## TOMATOES.

Tomato breeding work has for its object the selection of strains which are resistant to wilt, and improvement in the yield and type of fruit produced. The progenies of a number of individual wilt-resistant plants, grown in a plat producing a badly diseased crop of tomatoes last year, showed some apparently significant differences in their ability to resist wilt. The more promising selections obtained will be further tested.

The main planting, comprising about 1,200 plants, is located on land that had not been previously planted with tomatoes. This planting produced a very good crop which was only slightly damaged by disease.

The yield of Insular Station Tomato No. 443×Dierner cross was unexpectedly high in view of the reduction in yield of the  $F_2$  generation due to wilt. All the second and third generation progenies of the past season were highly variable and promising selections were made from each of them. Prolific crossed with Stone and Globe with Prolific produced several fruits, each weighing a pound or more. One row of 48 plants did remarkably well, producing on the average 925 grams (2.04 pounds) of fruit to the plant, although they were not watered after their first day in the field and the rainfall during their growth amounted to only 10.77 inches.

#### MUSKMELONS.

Third and fourth generation plants of a native muskmelon crossed with Salmon Tint Pollock and with Hybrid Casaba produced fruits having both hard and soft rinds. None of the fruit came uniformly true to seed. Further selection will be made for yield, quality, uniformity of type, and for resistance to mildew.

#### BANANAS.

Plants which were selected for resistance to the Panama disease made slightly more vigorous growth than did unselected plants. Tobacco stems and wood ashes when applied to the soil had no apparent effect on plant growth or on the disease.

#### MISCELLANEOUS WORK.

Seedlings of the Duncan and Triumph grapefruit cross,  $2\frac{1}{2}$  years old, set out in the spring, made fine growth.

At 15 months after planting, biennial white sweet clover made light growth and produced practically no seed. It gave place to grass and weeds and did not seem to be adapted to island conditions. Seed of Hubam clover, raised from a few plants during the spring, will be given further trial.

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### REPORT OF THE ENTOMOLOGIST.

By W. V. TOWER.

#### CITRUS SCAB.

Citrus scab is the worst pest with which the citrus fruit grower in Porto Rico has to contend. During the early years of the industry only young trees were attacked, but within recent years many old trees that once bore fine crops have produced fruit that is practically worthless for shipping.

A cooperative spraying experiment for citrus scab, started with one of the largest growers on the island, has given encouraging results during its first season. Some 3,000 trees setting blooms in December, January, and February were given four sprayings with a 3-4-50 Bordeaux oil emulsion carrying one-half per cent of oil. Usually the early winter bloom is not heavy, and when it comes during a cold rainy period, such as this did, the fruit is likely to be scabby. The first blooms appearing December 15, being few in number, were not sprayed until December 29. The second spraying was applied January 27, the third February 13, and the fourth.

March 9. No definite spraying program could be adhered to owing to the very unsettled weather and the small amount of fruit set from the first blooms. Fruit coming on after the final application of Bordeaux oil emulsion had been made was sprayed with lime and sulphur to kill the rust mites which were appearing. These trees produced 94.4 per cent clean fruit, 5.2 per cent showing a trace of scab, and 0.4 per cent which was spotted with scabby areas.

Trees in a check plat where the groves were the most severely infected and on which the early morning sun did not shine, gave 10 per cent clean fruit, 44.7 per cent showing a trace of scab (Pl. II, fig. 1), 27.5 per cent showing some scabby areas (Pl. II, fig. 2), 17.5 per cent which was badly scabbed but not knotted (Pl. III, fig. 1), and 0.3 per cent which was knotted and literally covered with scab (Pl. III, fig. 2). Sprayed trees in the same grove produced 90.6 per cent clean fruit, 9.3 per cent showing a trace of scab, and 0.1 per cent showing some scab areas.

Groves in the same vicinity showed a very high scab infection. One unsprayed grove produced 3.5 per cent clean fruit, 17.3 per cent showing a trace of scab, 24.4 per cent showing some scabby areas, 50.3 per cent which was badly scabbed but not knotted, and 4.5 per cent which was knotted and literally covered with scab.

Another grove on the same property was divided into three plats, the first two of which were sprayed four and two times, respectively, and the third of which was left unsprayed. The yield of clean fruit per plat was 91.2, 83.9, and 24.5 per cent, respectively.

A grove of 900 trees, sprayed January 13 and April 12 with Bordeaux oil emulsion (3-4-50, to which was added  $\frac{1}{2}$  per cent of oil emulsion) produced 97.3 per cent clean fruit. These trees set a very heavy bloom on May 11 and the grove was sprayed with lime and sulphur.

Another grove of 800 trees, which also blossomed late, was sprayed on April 5 and May 8 with Bordeaux oil emulsion. The blossoms appeared April 29 and were heavy May 9. The trees produced 93.8 per cent clean fruit, 6 per cent showing a trace of scab, and 0.2 per cent which was slightly spotted with scabby areas.

Recent tests with the oil emulsion were made at the station with grapefruit trees bearing 6-months-old fruit. The solution applied had the following strengths, 1,  $1\frac{1}{2}$ , 2,  $2\frac{1}{2}$ , and 3 per cent of oil emulsion, and where applied neither the leaves or fruit burned nor did the leaves drop.

In all tests made with Bordeaux and oil (3-4-50-0.5), only a few of the young shoots burned. No small fruit or open blossoms were injured by this strength of spray. A few unopened blossoms burned and dropped, but no serious loss of leaves occurred.

The results obtained with Bordeaux oil emulsion are most encouraging, but the spray should not be used unless the grower is prepared to fight the scale, which is sure to follow. The campaign should be well planned and the spray thoroughly applied. Only the best spraying material should be used and a constant watch should be maintained for scale and rust mites.

For any extended spraying program with Bordeaux oil emulsion, sufficient stocks of concentrated solutions of lime, copper sulphate, and oil emulsion should be made separately and stored in advance so that everything will be ready when the rush of spraying starts.

**REPORT OF THE SPECIALIST IN FARM MANAGEMENT.**

By H. C. HENRICKSEN.

**THE CITRUS FRUIT INDUSTRY.**

At the beginning of the shipping season 1921-22 freight service between Porto Rico and New York was inaugurated by a steamship company having three vessels, two of which had refrigeration and ventilation and were capable of carrying upward of 40,000 boxes of fruit each, and the third of which had ventilation but no refrigeration. At the beginning of the shipping season 1922-23 another steamship company installed refrigeration and ventilation in a large vessel plying between Porto Rico and New York with the result that the entire fruit crop can now be shipped, and with less loss than formerly, provided the recommendations made by the experiment station are followed.

Facilities were provided by the first-mentioned company to enable the writer to observe conditions in the various holds of its vessels. Two trips were made from Porto Rico to New York with fruit which was literally followed from the field to the consumer. This work terminated the investigations undertaken to ascertain some of the factors affecting the price of citrus fruit, and the results were prepared for publication during the year.

Laboratory tests were undertaken during the latter part of the year for the purpose of helping local growers overcome some of the difficulties encountered in artificially coloring fruit by means of gases. It was found that practically all gases may produce spotting of the rind when they strike the fruit with some force, and that a chemically active gas, such as chlorin or sulphur dioxid, when allowed to settle on the fruit, may produce spots on the rind. It was also found that vapor of ether, chloroform, and ethylene impart an odor or taste to the pulp, and that all or any mixture of gases or vapor in which there is little or no oxygen cause the fruit to develop an unpleasant odor or taste after 24 to 48 hours. Loosening of the stems may occur, resulting in *Diplodia* decay, when the fruit is exposed for considerable time to any gas except oxygen. "Popping of the stems," however, is not caused by the gas, but rather by the mixture of an insufficient amount of oxygen with the gas. It may be prevented by forcing fresh air into the coloring room in such quantity as to keep the oxygen supply at about 15 per cent of the atmosphere, and by keeping the air in motion. The results of the investigation suggest the even distribution of the gases by means of a fan placed outside a coloring room having inlet and outlet tubes. This will permit of the room being kept closed and the air rotated instead of renewed. The supply of gas should be ample and contain a higher percentage of acrid substances than is found in the exhaust products of gas engines. For this purpose the heavier oil products, such as tar or pitch, should be given a thorough trial. The mixture of gas and air should contain enough oxygen to provide for the unhindered respiration of the fruit and also enough gases of the kind that attacks coloring matter to produce the desired color change.

**PINEAPPLES.**

The pineapple is one of the most profitable fruit crops in Porto Rico when growing conditions are favorable. Due to an apparent

soil exhaustion independent of the plant food supply and to a deterioration of the plant relative to the production of fruit and slips, this is not always the case. Slips which formerly had free entrance from Cuba are now admitted subject to a duty of 25 per cent ad valorem. This and the increasing scarcity of slips will likely curtail the pineapple industry in Porto Rico unless some method is found for the local production of sufficient vigorous and prolific slips to plant new fields. Much research work covering several years is involved in the study of these problems, but when it is finished the results should furnish answers to many problems in addition to those mentioned.

#### MISCELLANEOUS WORK AT THE SAN JUAN OFFICE.

Agricultural Extension Notes dealing with original research work and subjects of a popular nature were again published during the year.

In January the writer gave a series of lectures at the insular experiment station at Rio Piedras to all the field agents of the insular department of agriculture and labor and to the agricultural teachers of the department of education. The lectures dealt with tropical horticulture and farm management adapted to local conditions.

Films and slides, obtained from the United States Department of Agriculture, were used to illustrate other lectures of an educational nature.

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#### REPORT OF THE ACTING PLANT PATHOLOGIST.

By C. M. TUCKER.<sup>3</sup>

##### A BROWN SPOT DISEASE OF RICE (*Helminthosporium* sp.)

The rice harvested from 37 test plats during the past season was observed to be discolored, in many instances, by small brown spots on the glumes (Pl. IV, fig. 1).

Early evidence of infection on the seedlings appeared at the collar, where a brown ring was apparent just below the first leaf sheath. The ring of infected tissue usually girdled the seedling. This ring is of light color and gives the infected area the appearance of being in the first stage of decay. The infection was usually confined to the outer layers of the collar tissues and did not cause the immediate death of the seedling. The young leaves were spotted with small oval, brown spots extending through the tissue to both sides of the leaf and often elongate in the direction of the long axis of the leaf, which was killed in many instances. Brown lesions sometimes appeared on the first leaf sheath, extending through the tissues but not penetrating the young inclosed leaf; the latter, however, usually developed spots of infection after emerging from the sheath. The roots of infected seedlings turned brown and died as the fungus progressed along them. In some instances, seedlings were killed by root infection alone, exhibiting no evidence of infection on the leafy portion (Pl. IV, fig. 2). In test tube cultures all the seedlings having infected roots died, while a few of those showing leaf in-

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<sup>3</sup> Affiliated with the Porto Rico College of Agriculture and employed temporarily by the station.

fection only, recovered. In each instance the death of the seedling was followed by the appearance on the roots and collar of a gray mycelium which grew and bore spores abundantly. As the plants matured the leaves became spotted with oval or elongated, dark brown, while in the center of each spot there was a gray area of dead tissue containing the mycelium (Pl. IV, fig. 3). The spots on the grain appeared as very small circular or oval, dark brown discolorations, shading toward the edge of the spot to a lighter brown. A portion of the grain had spotted endosperms which were so deep as to fail to be removed during milling and polishing.

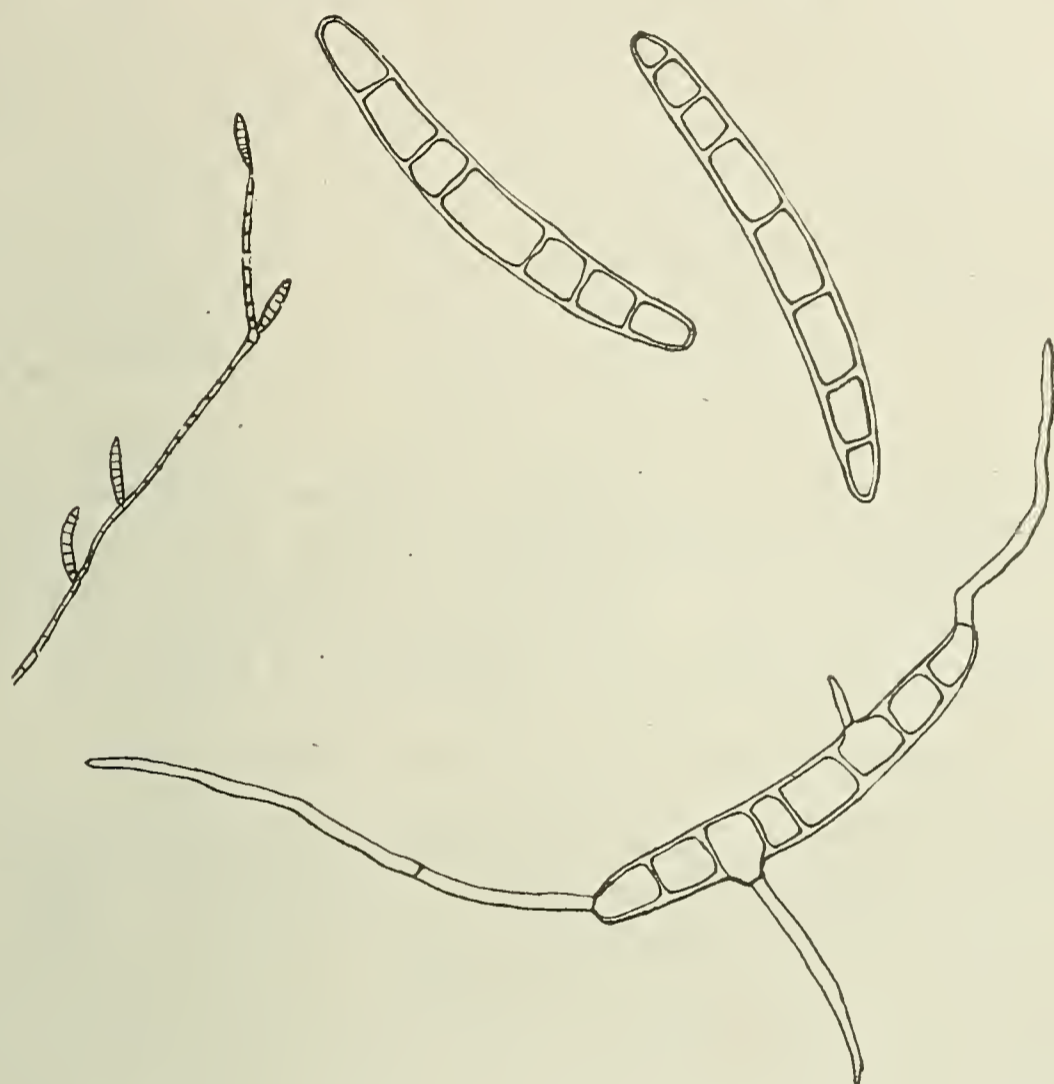


FIG. 6.—Conidiophore, spores, and germinating spore of *Helminthosporium* sp. from rice.

The plants were classified as to infection on coleoptile, root, or on both, to determine where the first symptoms appeared and to get the infection and germination percentage of each seedling. Many of the seeds germinated poorly and were covered with a mycelium characteristic of *Helminthosporium*. Seeds which failed to germinate supported a thick growth of the fungus. More than half of the infected seedlings showed symptoms of infection on both root and coleoptile, which seems a natural result of infection by a seed-borne organism. Of the 207 infected seedlings, 176 died before reaching a height of 6 inches.

Evidently the fungus does not penetrate the leaves in every case of coleoptile infection. The soil is a better medium for the growth of the seedlings than is the nutrient solution and increases their power of resistance.

Examination of the mycelium from diseased seed, seedlings, roots, etc., proved it to be of the same fungus (*Helminthosporium* sp.). Pure cultures were obtained by making direct transfers from these colonies to potato agar slopes. Investigations failed to disclose evidence of a sexual or perfect stage of the species. It is thought that secondary infections occur on the leaves and heads from primary seedling infections and that diseased seed will produce a diseased crop. Disease-free seeds planted in the field at considerable distance from other rice produced seedlings showing no symptoms of the disease, but when the plants had reached a height of 6 to 10 inches the characteristic spots began to appear on the leaves. This particular type of infection seemed much less virulent than the seedling infection and could not have had its source in the soil, since rice had not been planted there in recent years. The infecting spores may have been carried by the wind from distant fields or from other hosts of the fungus. Further investigation will determine whether any of the species are identical with the species of *Helminthosporium* attacking cereals and common grasses (figs. 5 and 6). Soil infection is a possibility if not a probability, but results to date indicate that seed infection is the primary source of disease.

Preliminary results at the station indicate that chemical disinfectants are of little value in controlling seedling blight of rice. The most practical means of control would seem to be in the selection of clean seed. Infection may readily be distinguished by the brown spotting on the seed coat. Examination of a sample of seed will easily determine the approximate percentage of infection.

#### A DISEASE AFFECTING GRAPEFRUIT TREES.

Numbers of grapefruit trees are dying in the Manati section from a disease which seems to have had its origin in a single tree and thence spread slowly but constantly in all directions. Affected trees assume a chlorotic appearance, the leaves turning yellow and the young growth showing more or less frenching. So far as it is known, affected trees have never been restored to normal condition. Ferric sulphate sprays, copper sulphate solutions as a soil drench, and heavy applications of various fertilizers have been of no avail. Slightly decayed specimens of the roots of dying trees were found to support a large variety of saprophytic fungi. A large number of plates, made by covering small bits of surface-sterilized root with agar, showed the constant presence of a *Fusarium* sp. This organism makes very sparse growth on agar media and on grapefruit leaf agar, but grows rapidly and produces an abundance of white mycelium on sterilized grapefruit roots. The freshly cut root of seedlings, when placed in contact with fungus-covered pieces of root, showed no evidence of disease.

The affected trees are growing in a red clay soil which is neutral in reaction. It may be that this soil contains in an unavailable form some essential plant food for these trees. The slow spread of the disease may be explained by some such peculiar slow change going on in the soil and subsoil. It is doubtful if an organism is responsible for the disease. As yet no recommendation can be made for its control.



